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Wave Data Processing and Analysis, Part 2: Codes for Coupling GenCade and CMS-Wave

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PURPOSE: This Coastal and Hydraulics Engineering Technical Note (CHETN) describes an application of wave data processing codes to generate representative wave conditions required as input to GenCade. This is the second CHETN in a two-part series detailing the process of coupling CMS-Wave with GenCade. This CHETN focuses on compiling binned wave conditions for input to CMS-Wave and the processing of CMS-Wave output files to generate input wave information for GenCade. The toolkit and an example dataset can be downloaded from *http://cirp.usace.army.mil/products/?tab=4*.

DESCRIPTION OF CODES: The approach used to integrate detailed nearshore wave information generated using CMS-Wave into GenCade involves a set of MATLAB routines that transform and bin-sort offshore wave information to develop representative input wave conditions for CMS-Wave. A second executable program (CMS2MAP.exe) is provided for processing the CMS-Wave output files for input to GenCade. The details of the MATLAB routines were described in Part 1 (CHETN-IV-97). Part 2 demonstrates the insertion of a wave data set into CMS-Wave and the subsequent processing of the CMS-Wave results. The Fortran executable (cms2map.exe) allows the user to convert a set of representative conditions to a time series input for GenCade. After a CMS-Wave simulation is completed, the user can run cms2map.exe to convert the SMS selhts.out file (or *.out) to a time series of wave conditions for input to GenCade. This executable requires the use of observation station output from CMS-Wave either as binned data or as a time series of wave conditions. As described in Part 1, the user provides a set of binned wave conditions and associated probabilities developed using the MATLAB routines. The purpose of binning the data is to reduce the computational effort required to run a full time series in CMS-Wave. A cursory description of CMS-Wave is provided here, for details please see CMS-Wave references (Lin et al. 2011; Lin et al. 2008). The example shown below continues the example from the Part 1 CHETN.

Steps for Using Codes. There are five main tasks (A-E) involved in integrating nearshore wave information generated using CMS-Wave into GenCade. These are summarized below. Before applying the Fortran code, the user needs to compile incident wave spectra for CMS-Wave and designate wave save stations.

A. Generate Incident Spectra for CMS-Wave

To run CMS-Wave, incident wave spectra must be generated for each wave condition. The input wave conditions are the binned wave conditions developed by the MATLAB code described in the Part 1 CHETN. The binned wave conditions are stored in the file

WaveBin_Table_Over_MinCount_Threshold.dat. The steps for using SMS to generate CMS-Wave incident spectra from the binned wave conditions are given as follows:

Step 1. Under the CMS-Wave menu, select **Spectral Energy**.

Step 2. Select **Create Grid** or upload an existing spectral grid using the import grid tab.

Step 3. Specify the number of frequency bin walls (30 walls results in 29 bins), frequency increment (Delta), and minimum and maximum frequencies. In Figure 1, the frequency range corresponds to wave periods of 3.0 sec to 25 sec. The angle distribution is not adjustable in CMS-Wave.

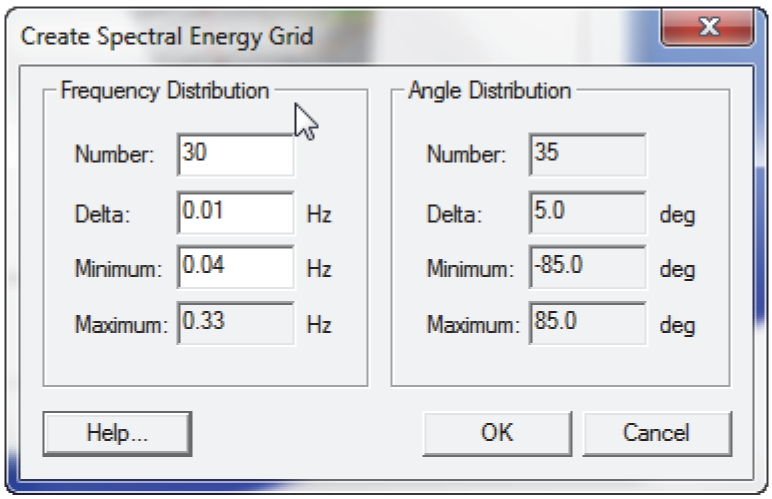

Figure 1. Spectral energy grid options.

Step 4. Once the new spectral grid is created right click on the **New_Spectral_Grid** and select **Generate Spectra** from the menu.

Step 5. Copy and paste the values of wave heights, periods, and directions from the WaveBin_Table_Over_MinCount_Threshold.dat into the corresponding columns. Use of default values listed in Figure 2 are recommended for *Gamma* and *nn* specifications. After completing the input table, click the **Generate** button.

Step 6. Export the spectra by clicking on the **Export Spectra** in the spectra generator. Be sure that the spectra file name matches the file name used in the CMS-Wave *.sim file.

B. Select CMS-Wave Observation Cells

Step 1. Determine the location where breaking waves occur in the target area. Wave observation stations should be positioned immediately offshore of the breaking depth of the largest wave (approximately 0.8 of the significant wave height).

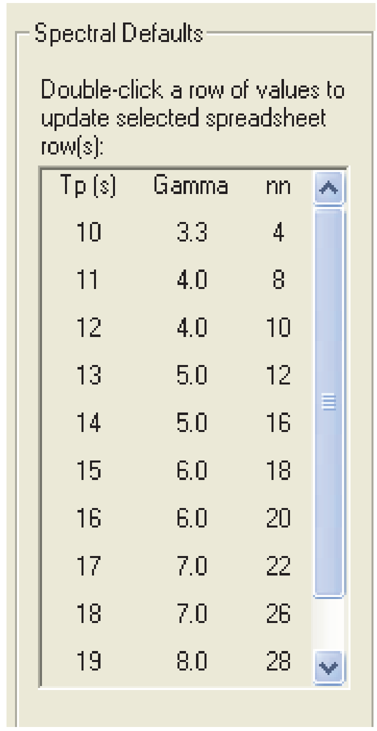

Figure 2. Spectral Defaults

Step 2. In the Cartesian grid module of SMS, select the Cell tool for specifying grid cells to serve as observation (monitoring) stations.

Step 3. Press the Shift key to select multiple cells along the desired contours or depths for observation stations. The use of multiple cells along the length of the GenCade grid captures the effects of complex nearshore bathymetry on wave conditions.

Step 4. Right click on the screen to display the Cell Attributes window (see Figure 3). Change the Cell Type from Default to Monitoring station.

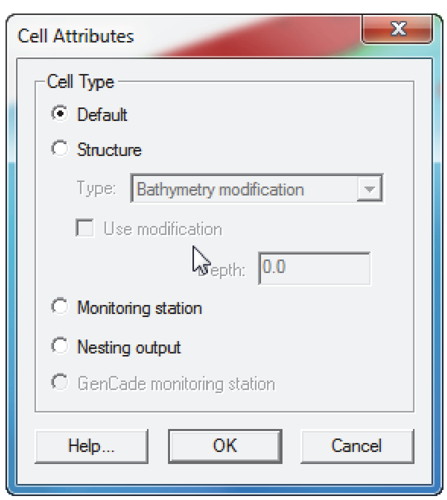

Figure 3. Cell attributes window.

C. Convert CMS-Wave Output to Representative Time-Series Data for Input to GenCade

Step 1. Inspect wave heights in the selhts.out (or *.out) file produced by the CMS-Wave to ensure wave heights at each monitoring cell are reasonable. Confirm the number of rows in the file equal to the number of observation stations multiplied by the number of wave events. If the *.out file is not deleted prior to subsequent CMS-Wave runs, results will be appended to the existing file and can lead to erroneous wave data in GenCade simulations.

Step 2. Prepare two input files for cms2map.exe:

- **cms2map.ctrl:** The control file that assigns input and output file names, directory paths, and input flags as given in Table 1.
- **JP_MultipleTimebin_Probability.dat:** An array of percent occurrence values. One value for each time bin for every CMS-Wave event simulated.

Table 1. Example of CMS2MAP .ctrl file.

#---	!---
# CMS-Wave control file (*.sim):	FORMATOUT: SMS_Map_Wave_File
#---	!---
SIMFILE: Demo1.sim	! [if FORMATOUT = SMS_Map_Wave_File]
#---	! Output Time Series SMS *.map file:
# CMS-Wave options file (*.std):	!---
#---	MAPFILE: Demo1waves.map
STDFILE: Demo1.std	!---
#---	! Output time series start date <yyyymmddHHMMSS>:
# CMS-Wave depth file (*.dep):	!---
#---	STARTDATE: 19990101000000
DEPFILE: Demo1.dep	!---
#---	! Output time series timestep (hours) <3>:
# CMS-Wave station output file (selhts.out):	!---
#---	TIMESTEPOUT: 3.0
SELHTSOUTFILE: selhts.out	!---
! Flag for CMS mode:	! Output time series length (hours) <8760>:
! <1> = time-series (process-based) mode;	!---
! <0> = steady state mode	TSOUTLENGTH: 8760.0 >
!---	!
CMSTSFLAG: 0	! ============== OPTIONAL INPUT FILE ==============
!---	!---
! [if CMSTSFLAG = 0]	! [if FORMATOUT = GenCade_Wave_File]
! Optional % Frequency of Occurrence file:	

```
!--------------------------------------------------
FREQFILE: JP_MultipleTimebin_Probability.dat
!--------------------------------------------------
! [if CMSTSFLAG = 0]
! Number of time periods to distribute output
! time series over <1>:
! (e.g, Annually = 1; Seasonally =4; Monthly = 12)
!--------------------------------------------------
NTIMEBINS: 2
!--------------------------------------------------
! [if CMSTSFLAG = 0]
! Flag for random temporal distribution:
! <1> = randomly distributed;
! <0> = same order as input wave events
!--------------------------------------------------
RANDOMFLAG: 1
!=========== OUTPUT ================
!--------------------------------------------------
! Flag for output format:
! <SMS_Map_Wave_File> = SMS Map File;
! <GenCade_Wave_File> = GenCade Wave Files
```

```
! Existing GenCade Control Filename:
!--------------------------------------------------
! GENFILEIN: Region_merge_08tst.gen

!**************************************************
! ! IF there is no existing *.gen file add the
! ! following cards to this control file:
!
!**************************************************
! !--------------------------------------------------
! ! GenCade Grid Origin:
! !--------------------------------------------------
! X0: 250000.0
! Y0: 165000.0
!
! !--------------------------------------------------
! ! GenCade Grid Azimuth:
! !--------------------------------------------------
! AZIMUTHGEN: 8.0
! !AZIMUTHGEN: equal
! If you want it to be the same as the CMS-Wave azimuth
! !--------------------------------------------------
! ! Number of GenCade Grid Cells:
! !--------------------------------------------------
! NX: 205
!
! !--------------------------------------------------
! ! GenCade Grid Cell Resolution/Width:
! !--------------------------------------------------
! DX: 300.000000
```

The JP_MultipleTimebin_Probability.dat file can be generated using the code discussed in the Part 1 CHETN. Each row of data contains the percent occurrence for each binned wave condition. The columns of the file represent the time bins for each binned wave condition. For the example shown in Figure 3, the percent occurrence file has two wave conditions each binned for half a year. The sum of the percents is less than 100 due to calm periods.

For preparing a new cms2map.ctrl file (see Table 1), the user may open a new Notepad file or use the demonstration *.ctrl file (template) available from the website. In the example file (Table 1), the lines that begin with either an "!" or a "#" are commented out, and are placed within the file for clarity, or to show cards turned off for this application. The example shows the cms2map.exe writing directly to a .map file instead of a GenCade file. To create a new GenCade file, the additional cards required would need to be turned on (e.g., remove the !) in the *.ctrl. For each card, the user can type the card name with a colon followed by the desired parameter value. The first four cards are the file names for input files for the CMS-Wave run (the full file name does not need to be used if all input files and the .ctrl file are in the same folder). CMSTSFLAG specifies whether the user wants to order the waves calculated by CMS-Wave (1) or to use frequency of occurrence values to distribute the waves (0). If 0 is selected, a frequency of occurrence file must be generated to include the number of occurrences for each wave event and time bin used in CMS-Wave. The frequency of occurrence should be listed as a percent; the code inserts calm wave conditions (0 m wave heights) until the total frequency reaches 100 percent. The "number of time bins" card is used to read the JP_MultipleTimebin_Probability.dat file produced by the MATLAB codes. RANDOMFLAG allows the user to either randomly distribute the wave events (1) or use the same order as the input wave events in CMS-Wave (0).

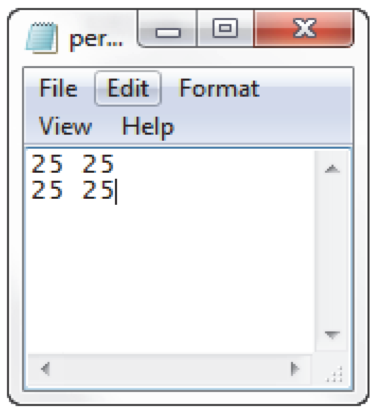

Figure 3. Example of percent occurrence file.

The next section of the CMS2MAP.ctrl file specifies the output for either a *.map file or a GenCade *.gen file. First, the user specifies the output file desired; SMS_Map_Wave_File signifies a map file and GenCade_Wave_File signifies a GenCade control file. If a map file is selected, the next card must be the desired file name for the *.map file. If a GenCade file is selected, the user must specify either an existing GenCade control file (*.gen file)or create a GenCade control file

The next three cards specify the start date, time step, and time-series length, respectively. If the user has an existing *.gen file, GENFILEIN specifies the file name of the input file. If there is not an existing GenCade *.gen file, the user can specify a new file by adding it to the last section of the *.ctrl file. The grid origin is specified by specifying the easting as X0 and the northing as Y0, the azimuth is either specified or set to be the same as the CMS-Wave grid. The number and size of the grid cells are specified with the NX and DX, respectively.

To execute cms2map.exe, place the cms2map.ctrl, cms2map.exe, and CMS-Wave project files in the same folder and launch the executable by double-clicking on it. The executable may also be run in the command prompt (see Figure 4).

```
                       cms2map
         +--------------------------------------+
                   Build: 02 AUG 2012
                       cms2map.exe

    PURPOSE:
      Converts CMS-Wave station output data (selhts.out)
      to either:

      1) SMS *.map file for GenCade wave input from
           SMS Map Module; or
      2) GenCade *.gen and *.wave files for direct
           GenCade wave input.

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 ******************************************************

Output time series timestep (hours):    3.000000
Length of output time series (hours):    8760.000
Number of time periods to distribute output time series over:            2
Start Date & Time (yyyymmddHHMMSS):         19990101000000
Flag for CMS mode:
  (1) = time-series mode; (0) = steady state mode:     0
Flag for random temporal distribution:
  (1) = randomly distributed; (0) = same order as input waves:     1
Output format:
  (SMS_Map_Wave_File) = SMS Map File;
  (GenCade_Wave_File) = GenCade Wave Files: SMS_Map_Wave_File
Output SMS time series file name: Demo1waves.map

 ******************************************************

Loading CMS-Wave *.sim file: Demo1.sim
Loading CMS-Wave *.std file: Demo1.std
Loading CMS-Wave selhts.out file: selhts.out
Loading CMS-Wave *.dep file: Demo1.dep
Loading % frequency of occurrence file: JP_MultipleTimebin_Probability.dat

 ******************************************************

Number of wave observation stations:           19

 ******************************************************

Number of input wave events:            3
Number of output wave events:         2920

 ******************************************************

Wave model grid origin:
   X (Easting):     329492.636700000
   Y (Northing):    3337124.55930000
Wave model grid rotation azimuth (deg):    108.700000000000

 ******************************************************
```

Figure 4. Executing CMS2MAP in command prompt.

D. Convert representative time series to GenCade wave forcing input

Step 1. cms2map.exe does two things: 1) produces annual wave data time series based on the frequency of occurrence of the input wave events, and 2) writes a *.map file for GenCade application in SMS.

Step 2. Load the *.map file to SMS as input to GenCade. An uploaded *.map file is shown in Figure 5 over the bathymetry for Ship Island.

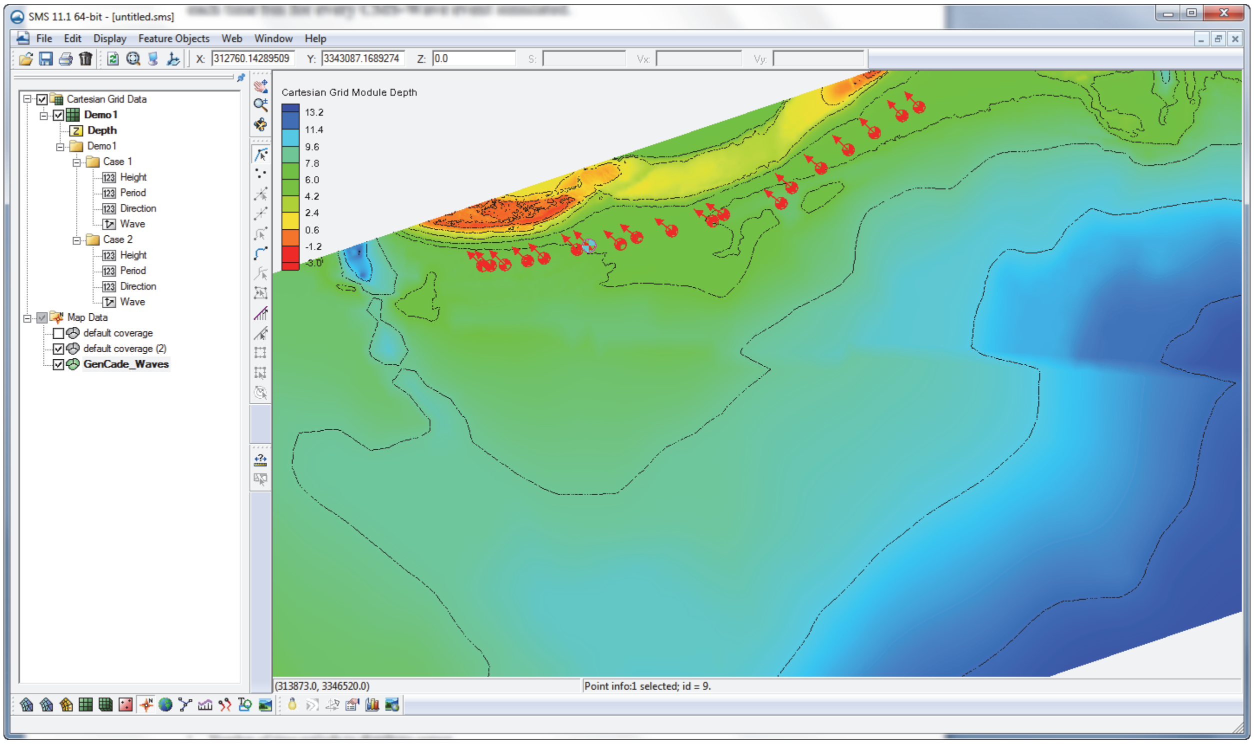

Figure 5. Multiple Wave Gauges along Ship Island

E. GenCade Setup and Execution

Wave input files for a GenCade simulation are now complete and GenCade can be run. Further information on the execution of Gencade can be found in the user's guide (Frey et al. 2012). Develop a new case in the GenCade conceptual model, convert the case to a GenCade domain, finalize input parameters, select the GenCade menu, and select ***<Run GenCade…>***. The new wave map files may be merged with existing map files by right-clicking on the map coverage and selecting **merge coverages**.

SUMMARY: This CHETN describes a Fortran executable used to develop representative wave climate datasets for a GenCade application as wave forcing from representative CMS-Wave cases. The binning of wave conditions for CMS-Wave modeling is described in the Part 1 CHETN. In the future, the wave data processing codes will be further developed and integrated with other existing tools and GUIs. The guidance provided is anticipated to change and users should consult the Coastal Inlets Research Program (CIRP) website (*cirp.usace.army.mil*) and the CIRP wiki (*cirp.usace.army.mil/wiki*) for additional information. The codes and example data set discussed herein can be downloaded from: *http://cirp.usace.army.mil/products/?tab=4*.

POINTS OF CONTACT: This CHETN was prepared as part of the Coastal Inlets Research Program (CIRP) and was written by Rusty Permenter (*Rusty.L.Permenter@usace.army.mil*, 601-634-2089) of the US Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) and Kenneth J. Connell (*Kenneth_Connell@golder.com*) of Golder Associates, Inc. Ashley Frey and Lihwa Lin provided peer-review of this publication.

For information about CIRP, please contact the CIRP Program Manager, Dr. Julie Dean Rosati (251-694-3719) or by email (Julie.D.Rosati@usace.army.mil). This CHETN should be referenced as follows:

> Permenter, R., K. J. Connell, and Z. Demirbilek. 2013. *Wave data processing and analysis, Part 2: Codes for Coupling GenCade and CMS-Wave*. ERDC/CHL CHETN-IV-98. Vicksburg, MS: US Army Engineer Research and Development Center.

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Lin, L., Z. Demirbilek, H. Mase, J. Zheng, and F. Yamada. 2008. *CMS-Wave: A nearshore spectral wave processes model for coastal inlets and navigation projects*. Coastal Inlets Research Program, Coastal and Hydraulics Laboratory Technical Report ERDC/CHL TR-08-13. Vicksburg, MS: US Army Engineer Research and Development Center.

Lin, L., Z. Demirbilek, R. Thomas, and J. Rosati III . 2011. *Verification and validation of the coastal modeling system, Report 2: CMS-Wave*. ERDC/CHL-TR-11-10. Vicksburg, MS: US Army Engineer Research and Development Center.

Connell, K. J. and R. Permenter. 2013. *Wave data processing and analysis tools for developing wave boundary forcing for CMS-Wave and GenCade numerical models: Part 1*. ERDC/CHL CHETN-IV-97. Vicksburg, MS: US Army Engineer Research and Development Center.